United States Department of Agriculture

NRCS Natural Resources Conservation Service

Wetlands, Mosquitoes, and West Nile Virus

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Indiana Biology Technical Note No. 4

Recent concerns over the spread of West Nile virus (WNV) have brought considerable attention to mosquitoes and their habitats.

To a large degree, West Nile virus is a disease associated with human habitats. Records show that the majority of cases of WNV reported in Indiana thus far have been associated with urban sites and human habitations, not near wetland sites. For example, in 2002 the Fort Wayne/Allen County Department of Health surveyed mosquito-breeding sites near human West Nile virus cases. The survey found that 66% of these breeding sites were TIRES.

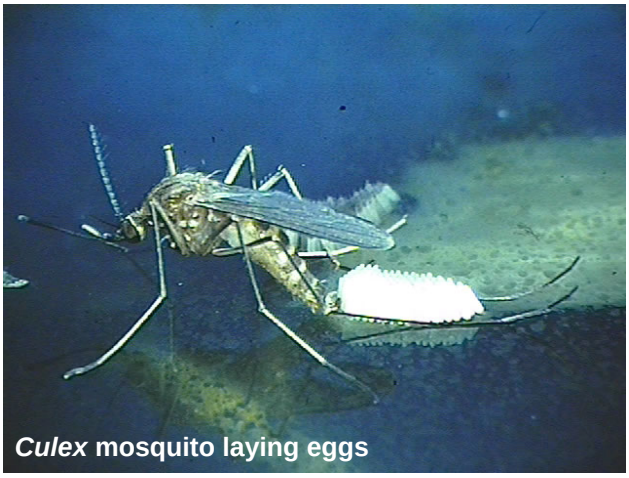
This document is intended to:

- Provide an understanding of the interaction between wetlands, mosquitoes, and WNV.
- Reduce the fear that wetlands are a primary breeding ground for mosquitoes carrying WNV.
- List ways to reduce mosquito-breeding areas around your home, and to prevent being bitten by mosquitoes.

WEST NILE VIRUS

The West Nile virus is a mosquito-borne virus that was first discovered in the West Nile District of Uganda in 1937. WNV spread across areas of Africa, Eastern Europe, West Asia, and the Middle East, eventually appearing in the Eastern United States in 1999. Although the exact origin of the WNV found in the U.S. remains unknown, the strain isolated from the 1999 outbreak is most closely related to that identified in Israel in 1998 from a dead goose.

The mosquito that has been most closely associated with transmitting West Nile virus in the United States, and in Indiana, is the Northern House Mosquito (*Culex pipiens*). The larvae of this species prefer to live in nutrient-rich, organic (often polluted) sites, such as leakage from septic tanks, abandoned swimming pools, clogged gutters, and similar enriched-water containers. *Culex* prefer birds to any other host. After feeding on a bird, it is more likely to seek out another bird than a person or other mammal.



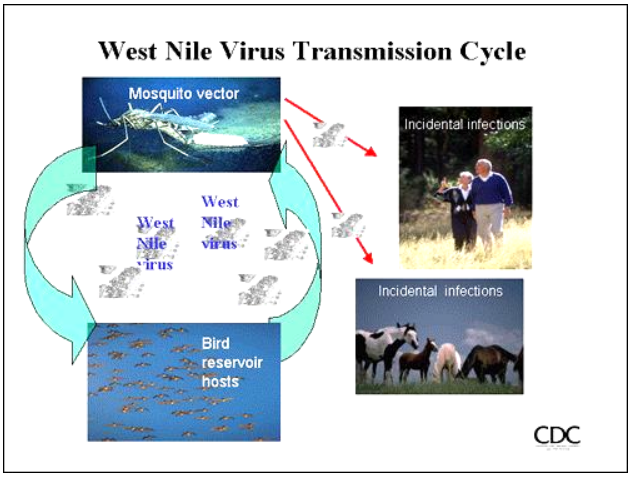
***Culex* mosquito laying eggs**

Culex are generally weak fliers and do not move far from home, although they have been known to fly up to two miles. While at least 43 other mosquito species in the U.S. have also tested positive for West Nile virus, it is still unclear which of these species are capable of acting as a vector for WNV.

There are many types of mosquitoes. It is important to note that not all mosquitoes carry WNV, not all mosquitoes feed on humans, and breeding habitat varies for each mosquito species.

WNV is spread to people by the bite of an infected mosquito. *C. pipiens* commonly lays its eggs in the stagnant waters of artificial containers in areas of human habitation. Mosquitoes acquire WNV when feeding on infected birds that have high levels of WNV in their blood. The virus is then stored in the mosquito's salivary glands and transmitted to humans or other animals during the mosquito bite.

Humans and domestic mammals are considered "dead-end" hosts, who do not contribute to the transmission cycle but can develop an illness because of infection. There is no evidence to suggest that West Nile virus can be spread from person to person or from animal to person contact (Centers for Disease Control and Prevention - CDC). The only known cases of people being infected with WNV from another person are through blood transfusions and organ transplants.



West Nile virus is a serious disease. However, statistically a person's risk of contracting WNV is low. Most people who are infected with the West Nile virus will not have any type of illness. It is estimated that 20% of the people who become infected will develop West Nile fever: mild symptoms, including fever, headache, and body aches, occasionally with a skin rash on the trunk of the body and swollen lymph glands.

The symptoms of severe infection (West Nile encephalitis or meningitis) include headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, and paralysis. It is estimated that 1 in 150 persons infected with the West Nile virus will develop a more severe form of disease. The CDC reported that of 4156 laboratory-positive human cases, there were 284 deaths nationwide from WNV in 2002.

WNV can be contracted by anyone of any age, but it is more likely to develop into a serious condition in individuals over 50 years of age and people with weakened immune systems. It is important, however, for *all* people to protect themselves from mosquito bites to minimize the risk of infection. While people may feel that they have no control over the risk of exposure, this is not true. Self-protection is still the best way to reduce your risk of contracting WNV. There are many ways you can prevent being bitten by mosquitoes **and** reduce mosquito-breeding areas around your home (see Prevention/Actions).

Reporting Dead Birds. While most survive, birds infected with West Nile virus can become ill or die. Dead birds in an area may mean that WNV is circulating between the birds and the mosquitoes in that area. Over 110 species of birds are known to carry West Nile virus, but the family Corvidae (including crows and blue jays) is most likely to die from the infection.

The public plays an important role in monitoring West Nile virus through reporting dead birds to state and local health departments. State and local agencies have different policies for collecting and testing birds. Many health departments will not start collecting sick or dead birds until the peak of the mosquito-breeding season. Once West Nile virus is detected in a county, further testing of dead birds is usually not necessary.

Contact your local health department to find information about reporting dead birds in your area. See the Indiana State Department of Health's website under References.

HEALTHY WETLANDS

Wetlands contribute important processes needed for an effective, well-functioning environment. Wetlands improve water quality through filtering and cleaning, help to limit flood flow, provide erosion control, and provide sites for recreational activities such as canoeing, fishing, and bird watching. Before European settlement, Indiana's wetlands covered approximately 25% of the state. As settlers moved west, wetlands were drained for timber, farming, and commercial and industrial development thus eliminating approximately 87% of the state's original wetlands.

Wetland-dependent wildlife species have been severely impacted by this significant reduction in the amount and quality of wetland habitat. Wetlands are among the most biologically productive habitats in the world. Wetlands warm quickly in the spring and produce abundant quantities of food for amphibians, reptiles, shorebirds, migrating birds, and waterfowl. Even small sites, much less than an acre, can produce hundreds of frogs, toads, and salamanders. Wetlands also provide critical links to other habitat types and wildlife populations.

Mosquitoes and other aquatic invertebrates are an integrated part of the wetland ecosystem providing a food source for many invertebrates, birds, bats, amphibians, and fish species. They also are crucial in the pollination of some rare species of plants, such as orchids.

Water is a necessary part of mosquito development, and areas of water sheltered from the wind by grass and weeds are preferred. Mosquitoes go through four separate and distinct life cycle stages: egg, larva, pupa, and adult. The time from egg laying to adult emergence varies with the species and with environmental factors such as temperature. About 200 mosquito species are found in the United States.

***Culex* mosquitoes are rarely found in healthy wetlands**

Muscatatuck WRP - Gerry Roach, NRCS

C. pipiens is rarely found in healthy wetlands. One of the significant differences between artificially created/modified water bodies and natural wetlands is the presence of predators. Healthy wetlands are home to many mosquito-eating predators.

Insects, wildlife, and fish that eat immature mosquitoes (larvae) in the water, or eat flying adults, are often present in wetlands. Frogs, salamanders, and many aquatic insects such as backswimmers, damselflies, water striders, dragonflies, and dragonfly larvae feed on mosquitoes. Wetland wildlife including birds (e.g. swallows and ducklings) and little brown bats also consume numerous mosquitoes.

These natural predators make wetlands less than ideal mosquito breeding sites. The two-acre Edmond Avenue wetland restoration project near Portsmouth, New Hampshire, for example, demonstrated a near 100% reduction in mosquito habitat and the virtual elimination of *Culex* species.

DEGRADED AND ALTERED WETLANDS

Research from South Dakota State University found that there were many more mosquitoes in degraded wetlands than in higher quality wetlands. Storm water runoff and incompatible surrounding land use practices adversely affect natural wetlands. This includes storm water runoff from urban and newly urbanizing areas and sediment from both agriculture and construction activities. Consequently, altered or degraded wetlands often have stagnant water, increased nutrient levels, and fewer natural mosquito predators. Maintaining the natural functions of wetlands (i.e., minimizing disturbance) is a good start to potentially reducing mosquito habitat.

Sometimes mosquito control programs recommend that wetlands be drained in order to control mosquitoes. While it is true that mosquitoes require standing water to breed, they also have a very short life cycle (from 4 days to a month), and the eggs can remain dormant for more than a year. Therefore, even after a wetland has been drained, it may still hold enough water after a rain to breed mosquitoes.

A *drained* area may actually produce *more* mosquitoes than it did when it was a wetland because it can no longer support natural mosquito predators.

Filling wetlands may force water to flow elsewhere, creating flooding or additional standing water. Filling or draining a wetland may also require both state and federal permits.

MANAGEMENT CONSIDERATIONS

In situations where wetlands pose an unacceptable risk of exposure to mosquitoes, attempting to reduce the mosquito population in the wetland may be a consideration. The following recommendations are primarily intended to increase mosquito predators, and to reduce mosquito-breeding areas.

- Design meandering channel connections between shallow and deeper waters to allow the flow of predators into and out of habitats where mosquitoes may breed.
- Design or manage wetlands to have at least some permanent or semi-permanent open water. More mosquito predators are found in open water areas. Mosquito larvae also tend to use emergent vegetation for protection from predators. Note, however, that the emergent fringe provides much of the wetland's wildlife value.
- Reduce nutrient-loading conditions by excluding livestock from the wetland. Install perimeter fences to keep cattle or other livestock from entering the wetland. Cattle in particular do considerable damage to the plants and cause a lot of sediment to enter the water.
- Reduce the number of isolated, stagnant, shallow areas (2-3 inches deep). Mosquitoes tend to congregate in warm, shallow, stagnant pools.
- Construct a buffer between the adjacent land and the wetland to filter nutrients and sediments.
- Construct artificial homes for mosquito predators such as purple martins, swallows and bats, which feed on adult mosquitoes.

Water level management. Some studies seem to indicate that maintaining high water levels in early spring, followed by a drawdown in late spring, will reduce mosquito populations. This process will tend to dehydrate mosquito larvae. After drawdown, the water is allowed to return to pre-drawdown levels. This type of management, however, can adversely affect aquatic vegetation and wetland-associated wildlife.

Larvicides. Chemical controls may be required if elimination or modification of breeding sites is not possible, and surveillance indicates the presence of infected mosquitoes that pose a risk to health. Larvicides, which target mosquitoes during their aquatic stage, are viewed as the least damaging to non-target wildlife in the application area. Several "reduced risk" options are available including *Bacillus thuringiensis israelensis* (*Bti*), a bacterial larvicide. These and other chemicals used by mosquito control agencies must be applied by qualified applicators and comply with state and federal requirements. An effective larviciding program must be part of an integrated mosquito control operation.

Ornamental ponds. In addition to the applicable recommendations above, consider the following suggestions to help reduce mosquito populations in ornamental ponds**:**

- Add a waterfall, or install an aerating pump, to keep water moving in the pond. Wave action or water movement on the pond surface is an important factor in reducing mosquito larvae survival rates. Note that natural ponds and most Indiana farm ponds will have adequate surface water movement and do not require additional aeration.
- Keep the surface of the water clear of free-floating vegetation and debris during the peak mosquito season, as some species of mosquitoes will tend to seek out surfaces on which to deposit eggs.
- Consider stocking fathead minnows, topminnows, or goldfish to reduce mosquito production. This type of biological control can be a viable control method where the use of pesticides is not preferred, particularly in artificial water bodies where concerns about the impact on non-target animals are lower.

Mosquito fish. Some county mosquito-control programs distribute mosquito fish (*Gambusia affinis*) as a means of mosquito control. Because *C. pipiens* normally thrive in artificial containers, it is unlikely that stocking fish in wetlands will result in significant levels of WNV control. Most Indiana wetlands that will support fish are often already inhabited by insect-eating fish as effective as mosquito fish. Studies also indicate that mosquito fish will feed on naturally occurring mosquito predators including amphibians, reptiles and other beneficial organisms found in wetlands.

Bug Zappers. Studies indicate that the use of bug zappers around the home to control mosquitoes are ineffective. In fact, the probability of being bitten by mosquitoes increases in the vicinity of these traps. The proportion of biting insects killed by bug zappers is minute, and many of the non-target insects killed are insect predators and parasites. In addition, studies indicate that bug zappers pose an immediate threat because of the release of insect-borne bacteria and viruses. They also release insect particles that are potential allergens and/or cause various respiratory conditions such as asthma.

HORSES

The pattern for severe infection in horses appears to be similar to that in people. Horses of all age groups can get WNV infection, but older or debilitated horses are probably more likely to be severely affected. There also appears to be less disease in horses over two years of age. Preliminary testing on farms where horses had died or were ill, found that most all of the other horses on the farm also had infection; they just did not show symptoms. The risk of horses getting West Nile virus is low, but of horses that become clinically ill about 25-33% die or need to be euthanized.

It is important to take preventive actions early, prior to the time of the year when mosquitoes are likely to bite and infect horses. Horses may become infected without showing any clinical signs. Fever is not a common sign.

USDA Animal and Plant Health Inspection Service

Clinical signs of West Nile virus in horses include:

- Ataxia or stumbling and un-coordinated movement;
- Depression or apprehension;
- Weakness of limbs, partial paralysis, or the inability to stand;
- Muscle twitching; or
- Death.

Vaccinate Your Horses. A vaccine intended to aid in the prevention of WNV in horses was given permanent approval in February 2003. This is a killed vaccine product, and its use is restricted to licensed veterinarians, meaning that it has to be acquired through a veterinarian.

For horses to be protected by vaccination, they need two doses three to six weeks apart at least one month before the mosquito season begins. The vaccine label stipulates that horses should receive an annual booster.

Note that vaccination, while providing excellent protection, is never 100% effective. While it is very rare (probably less than 1%) there will be some vaccinated horses that become ill and die. Because horses are sensitive to many chemicals

and surface insecticides are not always effective, environmental prevention is the preferred alternative. Other options to consider include placing insect growth regulators (such as Pre-Strike®) in water troughs, which prevents mosquito larvae from becoming adults.

Just as in humans, there is only symptomatic treatment, nothing will cure or kill West Nile virus. Most horses and people survive the clinical disease. For horses that survive, a full recovery is likely. Horses vaccinated against eastern equine encephalitis, western equine encephalitis, or Venezuelan equine encephalitis are NOT protected against WNV.

Information in this section was provided by the Indiana State Board of Animal Health and taken from the Animal Disease Alert, *West Nile Virus: Protecting Your Horses* by the USDA Animal and Plant Health Inspection Service (APHIS). The Alert, found in the References section, also has more information on horses and reducing mosquito-breeding sites, use of insect repellants, and reducing outdoor exposure.

PREVENTION / ACTIONS

Mosquitoes breed in standing water. Any place where water that stands for more than a week is sufficient to breed mosquitoes. Eliminating mosquito habitat in your backyard is the primary method for minimizing mosquito population booms.

Take the following steps to reduce mosquito-breeding opportunities around your home:

- Eliminate or empty any artificial water-collecting containers such as unused buckets, water troughs, and wheelbarrows, etc., when not in use.
- Clean out house roof gutters.
- Clean bird baths and animal water bowls at least once a week
- Empty plant pots or drip trays at least once a week.
- Get rid of unused tires, or keep them under cover, so they do not collect water.
- Clean and chlorinate outdoor swimming pools, saunas and hot tubs. If not in use, keep empty and covered.
- Check for standing water below air conditioner drain outlets and outdoor faucets.


Tires are frequently used as mosquito breeding sites

- Drain and cover boats.
- Check for standing water especially after any rain, watering the lawn or garden, or after washing the car.
- Drain culverts and ditches containing stagnant water.
- Drain or cover old cisterns.
- Level the ground around your home so water can run off or be absorbed evenly and not collect in low spots.
- Fill or drain tire ruts.
- Check for soggy areas over septic absorption fields.

Take these actions to reduce your contact with mosquitoes:

- Use a mosquito repellent that contains DEET (N,N-diethyl-meta-toluamide) and follow label directions. For details on when and how to apply repellent, see *Insect Repellent Use and Safety* on the CDC West Nile virus web site. Information on DEET is also available from the chemical fact sheet listed under U.S. EPA. (See References).
- Wear clothing that covers the skin such as long sleeve shirts and pants when out after dusk or in shaded areas during the daytime.

- Reduce outside activity during dawn and dusk when mosquitoes are actively feeding.

Eliminating sources of stagnant water can reduce potential breeding sites for mosquitoes

- Make sure that doors and windows have tight-fitting screens. Repair or replace all screens that have tears or holes.
- Use the proper type of light outside: incandescent lights attract mosquitoes, whereas fluorescent lights neither attract nor repel mosquitoes.
- Be aware that crowds or other "mass gatherings" give off large amounts of carbon dioxide, which can attract more mosquitoes from a greater distance.
- If your activities take you into wetlands, consider that West Nile virus infections usually peak in late summer and early autumn, before mosquito numbers are reduced by hard freezes.
- Vitamin B and "ultrasonic" devices are NOT effective in preventing mosquito bites.

Prevention and control of West Nile virus and other arboviral (short for arthropod-borne) diseases are most effectively accomplished through integrated vector management programs. These programs should include surveillance for West Nile virus activity in mosquito vectors, birds, horses, other animals, and humans, and implementation of appropriate mosquito control measures to reduce mosquito populations when necessary. (CDC)

DISCLAIMER

West Nile virus is new to North America and there are still many unknowns. Every attempt has been made to see that the material presented in this technical note was the latest information available at the time of its publication. However, be aware that scientific research and information is constantly changing. Please contact the agencies and resources listed in the REFERENCES section for the most current information regarding the interaction of West Nile virus, mosquitoes and wetlands.

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IN State Board of Animal Health (ISBAH)
www.in.gov/boah (877-747-3038), or
animalhealth@boah.state.in.us (317-227-0320)

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